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ABSTRACT

The literature on performance differences in various tasks as a function of reflection-impulsivity (R-I) is reviewed in this publication. A series of four experiments is then described which involve the cognitive-perceptual basis of R-I of children on a picture recognition memory task. Results from these studies indicated the following important, but tentative, conclusions about the process of picture recognition memory and the underlying perceptual basis of the R-I dimension in children: reflective and impulsive children differ in their propensity to engage in a detailed visual feature analysis of stimulus arrays; the process of visual feature analysis is perhaps the most important component in the underlying basis of R-I; strong inferential evidence was provided that picture recognition memory is primarily a process of visual feature analysis in which the role of verbal labels is minimal and indirect; recognition memory performance is susceptible to differential instructions which emphasize care versus quickness; recognition memory for pictures appears to increase over the elementary school years; and the Selfridge-Neisser model and the recognition paradigm are useful for future research. It was suggested that future research should be performed in this area. (Author/RB)

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REFLECTION-IMPULSIVITY (R-I): VALUE AND LIMITATIONS FOR UNDERSTANDING COGNITIVE PROCESSES IN CHILDREN

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Abstract

The literature on performance differences in various tasks as a function of R-I were reviewed. A series of four experiments was described in detail. These studies represent an attempt to specify the cognitive-perceptual basis underlying the R-I dimension. These studies were concerned with the performance of reflective and impulsive children on a picture recognition memory task.

Results from these studies indicated several important, but tentative, conclusions about the process of picture recognition memory and the underlying perceptual basis of the R-I dimension in children: (a) Reflective and impulsive children differ in their propensity to engage in a detailed visual feature analysis of stimulus arrays. (b) The process of visual feature analysis is perhaps the most important component in the underlying basis of R-I. (c) Strong inferential evidence was provided that picture recognition memory is primarily a process of visual feature analysis in which the role of verbal labels is a minimal and indirect one. (d) Recognition memory performance is susceptible to differential instructions which emphasize care vs. quickness. (e) Recognition memory for pictures appears to increase over the elementary school years. (f) The Selfridge-Neisser model is a useful heuristic, and the recognition paradigm used is a promising vehicle, for future research.

The results also suggested several caveats regarding the theoretical and practical utility of R-I as a conceptual tool for understanding individual differences in cognition. (a) The reliability of the Matching Familiar Figures (MFF) test over time is not impressive. (b) Since few investigators have looked at "fast-accurate" and "slow-inaccurate" subjects (typically 20-40% of the children at any age level), our understanding of individual differences has been severely limited. (c) It is highly likely that factors other than R-I

account for the largest portion of the variance in recognition memory, concept identification, and many other cognitive processes. (d) The data collectively argue that R-I performance differences do not reflect broad cognitive dispositions, but rather reflect quantitative differences in a process of visual feature analysis. (e) The magnitude of R-I effects is singularly unimpressive, both correlationally and experimentally (although consistent "significant" effects are obtained).

It was suggested that future research be directed toward the investigation of the conditions under which recognition memory and memory strategies might be enhanced for any child, reflective or impulsive.

REFLECTION-IMPULSIVITY (R-I): VALUE AND LIMITATIONS FOR UNDERSTANDING COGNITIVE PROCESSES IN CHILDREN

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Cognitive styles have been defined as individual variations in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information (Kogan, 1971, p. 244). Cognitive styles are different from "abilities" in that abilities concern the level (i.e., "quantity") of performance or skill, whereas cognitive styles emphasize the manner and form of cognitive performance. Throughout the psychological literature, one finds reference to such terms as cognitive styles, cognitive strategies, cognitive control principles, and modes of information processing. The distinctions are probably more a matter of differences in the investigators' theoretical orientation than of differences in the phenomena, but the distinctions have important implications for the educational process. For example, it matters greatly whether variation in cognitive functioning is attributed to ego structures or to acquired habits of processing information. In the former case, efforts would likely focus on the design of educational treatments intended to take advantage of the child's "innate" capacities; in the latter, efforts would likely focus on possible modification of the child's modes of information processing so that he or she will better profit from current educational treatments. Of course, these two approaches are not necessarily mutually exclusive (Wang & Siegel, 1975). The complicated issues of modifiability (reviewed by Denney, Note 1) and the differential conceptualization of cognitive style as capacity or strategy (reviewed by Kogan, 1971) are too involved to deal

with in this report. In general, however, styles possessing the quality of a capacity (e.g., Witkin's analytic-global dimension) are more resistant to modification than are those styles having the properties of a strategy where the individual selects a mode of approach to the task among others also available to him (e.g., conceptual groupings in sorting tasks).

Messick (1970) lists and describes nine separate cognitive styles that have been the object of theoretical and empirical investigation: field-independence vs. field-dependence, scanning, breadth of categorizing, conceptualizing styles, cognitive complexity vs. simplicity, reflectiveness vs. impulsivity, leveling vs. sharpening, constricted vs. flexible control, and tolerance for incongruous or unrealistic experiences. Kagan (1966a) and Kogan (1971) have argued that of these nine, the dimension of reflection-impulsivity (R-I) has the most direct implications for the educational process as this dimension involves the child's evaluation of his own cognitive products, that is, his willingness (or "capacity") to pause and reflect on the accuracy of his hypotheses and solutions in cognitive tasks involving response uncertainty.

Both Kogan (1971) and Kagan and Kogan (1970), in their massive reviews of the literature on individual variation in cognitive processes, conclude that the dimension of reflection-impulsivity (R-I) is a reliable and useful dimension along which to conceptualize cognitive style in children. Although R-I can be assessed with a number of instruments, the Matching Familiar Figures (MFF) test is now consistently used as the basic index. The MFF was developed by Kagan, Rosman, Day, Albert, and Phillips (1964) and has been demonstrated to be a reliable means of evaluating a child's relative position on the R-I dimension (Kagan, 1965a, 1965c, 1966a, 1966b). In the MFF, the child is shown a standard stimulus and asked to choose the one of several strikingly similar variants that exactly matches the standard. (The number of variants and the subtlety of the distinctive features have been typically varied so as to be developmentally appropriate for the sample under study. Generally, there are six variants

for elementary school children and eight variants for older children and adults.) Mean response time to the first hypothesis (response) and the total number of errors for all items are the major dependent variables.

Over an age range of five to eleven years there is a progressive increase in response time and a corresponding decrease in errors (Kagan et al., 1964). The correlations between these two variables are negative for all ages and range from the low .40s to the high .60s. The R-I dimension appears to have both short-term and relatively long-term stability. Yando (Note 2) found that over a ten-week period, second-grade children yielded an average correlation for response time of .70. Over a one-year period, the stability coefficients have ranged from the high .40s to the low .60s, but these coefficients drop to the low .30s over a period of two and one-half years (Messer, 1970). There is considerable generality of R-I over diverse tasks. At least the tendency to respond quickly or slowly is not confined to the MFF, but is manifest across a large variety of tasks that entail response uncertainty (Kagan et al., 1964) and is characteristic of tasks in which the child must generate his own alternative hypotheses (Kagan, 1965a). Intertask correlations have ranged from the .40s upwards.

A number of correlational studies by Kagan and his associates have shown consistent relationships between MFF response times, MFF errors, and "school-related" tasks. The correlations between R-I and ability measures are typically positive for response time and negative for number of errors. Kagan, Pearson, and Welch (1966) explored the relationship between R-I and inductive reasoning in a sample of first graders. Children who had faster MFF response times (and a greater number of MFF errors) responded more quickly and made more errors on two of three tasks of inductive reasoning. Kagan (1965c) found that in a sample of first graders, errors in reading prose were related to a disposition toward "impulsiveness" (short MFF response times). Kagan (1965b) found that third-grade impulsive children (short MFF response time or high MFF errors) made more

errors of commission in a task involving serial recall of familiar words. (It should be noted in passing that these relationships still obtained when Wechsler Intelligence Scale for Children Verbal IQ was partialled out.)

These studies have implied that, at a given age level, the more reflective the child, the more differentiated and adequate the strategy he employs in generating and evaluating his solutions in tasks involving response uncertainty and a number of response alternatives. But there is a problem: How does one decide that a child is "impulsive" or "reflective"? Clearly, this classification must depend on the joint operation of MFF response time and MFF errors. If classification depended only on response time, Kagan would surely have called the children "fast" or "slow" responders; if it depended only on MFF errors, Kagan would surely have classified the children as simply "accurate" or "inaccurate." Kagan (1965b) has argued that response time is the primary operational index of R-I, and that errors are the secondary index. In point of fact, in a series of post hoc analyses, Kagan (1965b) defined R-I in terms of both measures: Children who responded slowly (MFF response time above the median) and made few errors (MFF errors below the median) were classified as "reflective"; children who responded quickly (MFF response time below the median) and made many errors (MFF errors above the median) were classified as "impulsive." In his most recent empirical work on R-I, Kagan (1965a) has employed these joint criteria as the basis for classification of "reflective" and "impulsive" children. In our research, we have consistently followed Kagan's operational definition of R-I by determining median errors and response times for each Age x Sex subgroup, and then determining R-I classification within each subgroup.

In a direct attempt to experimentally test Kagan's notion that reflective children can better generate and evaluate their own cognitive products, Nuessle (1972) studied the hypothesis-testing proficiency of fifth- and ninth-grade reflective and impulsive children using a blank-trial procedure developed by Levine (1966). They argued that younger children might be less

efficient as "focusers" because they were more impulsive in their problem-solving approach than older children. The ability to inhibit dominant responses or first-available solutions is a valuable problem-solving technique (Kagan et al., 1964; White, 1965). The young child may not be lacking in memory capacity so much as not employing the capacity he does have in an efficient manner. As predicted, ninth graders were more efficient focusers than fifth graders. Thus, the developmental differences in focusing, reported by Eimas (1969, 1970) and Ingalls and Dickerson (1969), also appear in this study. Also, as predicted, reflective children were more proficient focusers than impulsive children at both grade levels. The interesting finding of a Grade x R-I interaction in focusing performance indicated that developmental differences in focusing proficiency are in part due to developmental differences in R-I. Specifically, Nuessle and Siegel argued that the learning and the use of "reflection" seem to result in more proficient focusing for older children, possibly because reflective style is associated with a more intense search-retrieval effort. Such an explanation is consistent with Maccoby's (1969) observation that ". . . it is not especially useful to think of a deficit in terms of the child's having a more limited 'information processing capacity' or 'memory storage capacity' in the usual meaning of these terms. Rather the problem would seem to be that the capacity the young child does have is not effectively employed" (p. 188).

In certain cases, the more proficient problem-solving performance of older children may be caused by greater assimilation of practice with certain information processing techniques such as the information selection strategy studied by Olson (1966). Because Nuessle's (1972) study was not designed to examine such factors, the data can only indicate that the R-I dimension has some theoretical and predictive value in explaining developmental differences in focusing.

Earlier research by Kagan and the study previously discussed have implied that at a given age level, the more reflective the child, the more

differentiated and adequate the scanning (internal and external) strategy he employs during the interval between stimulus presentation and initial response in a task involving a number of simultaneously available alternatives. However, this relationship was not demonstrated, either correlationally or experimentally. Several recent studies have experimentally investigated relationships between R-I and visual scanning strategies on the MFF.

Siegelman (1969) used a version of the MFF in which the child could expose only one variant at a time. She found that impulsive fourth graders ignored twice as many MFF variants per item as did reflective fourth graders, while reflective fourth graders distributed their attention more evenly across the standard and the variants. Drake (1970) recorded eye movements while the child was performing the MFF and found that impulsive third graders made fewer standard-variant comparisons on the MFF than did reflective third graders. When Drake's (1970) and Siegelman's (1969) data are looked at together, an interesting pattern emerges which seems to suggest a "strategy" difference between reflective and impulsive children. Siegelman's subjects were tested with a six-variant MFF, Drake's were tested with a four-variant MFF. Siegelman's reflective children looked at an average of 4.9 variants (out of 6) per trial; Drake's reflective children looked at an average of 3.3 (out of 4). On the other hand, Siegelman's impulsive children looked at an average of 3.2 variants (out of 6), as did Drake's impulsive children (out of 4). It could be hypothesized that the impulsive child has lower standards for acceptability of a solution and will thus come upon a solution sooner--looking at more variants is irrelevant for him. It is as though the more variants a reflective child is given, the more he feels obliged to reject before he gives an answer.

Odom, McIntyre, and Neale (1971) compared the perceptual learning of reflective and impulsive kindergarten children. The performance of reflective subjects indicated that they perceived and evaluated information based on the feature differences of stimulus arrays; the information

processed by the impulsive subjects could not be clearly identified. One might account for these data either by arguing that reflective and impulsive children differ in the degree and amount of cognitive evaluation of their solutions, or by arguing that cognitive style limits the amount of analysis of task information. However, given the data, neither argues for differences in other aspects of cognitive processing. That is, basic cognitive operations involving both hypothesis-testing and decision rules are utilized by both reflective and impulsive children, or they would not have been able to solve the training problem (which they did).

Vurpillot (1968) investigated visual scanning strategies and their relationship to performance on a task in which subjects had to make same or different judgments on two pictures containing multiple cues. Eye-movement data indicated that young children's criterion for identity was based on finding no differences after comparing the two pictures on only a few of their components. The MFF requires that the subject find the one among six or eight variants that exactly matches the standard. Thus, as in Vurpillot's task, if search is hasty, minor differences among variants might be easily overlooked and frequent errors made. To test this notion, Zelniker, Jeffrey, Ault, and Parsons (1972) recorded eye fixations of third-grade children on the MFF. Reflective and impulsive children did not differ in their scanning strategy on the MFF. Although reflective children spent more time at the task than did impulsive children, the greater mean number of fixations and the greater mean number of variants fixated by reflective children appeared to be direct correlates of the time the subject observed the card. A subsequent study by Ault, Crawford, and Jeffrey (1972) similarly obtained results which indicated that all subjects used the same basic strategy of making comparisons between the standard and one variant or between two variants; reflective children, however, were more systematic and made a greater proportion of these comparisons than did impulsive subjects.

In general, the data from studies which have looked at eye movements on the MFF are equivocal as to whether there are "strategy" differences (i.e., qualitative differences in task approach) between reflective and impulsive children, or whether the differences are merely quantitative (i.e., reflective children do more finely-grained scanning of variants). The studies by Drake (1970), Odom et al. (1971), and Zelniker et al. (1972) tend to suggest that reflective and impulsive children perform different kinds of feature analyses of stimulus arrays (i.e., they suggest qualitative differences). However, these suggestions remain but speculations as to the cognitive-perceptual basis for the observed performance differences. It is clearly possible that R-I performance differences reflect quantitative differences in a specific visual "search" or "feature-testing" process rather than qualitative differences in task approach or in broad "cognitive dispositions." Prior to further speculation, it is necessary to demonstrate differences in the extent to which reflective and impulsive children can use feature differences on a task that requires visual feature analysis for successful performance.

The four studies to be discussed represent an initial attempt to specify at least one of the perceptual-cognitive bases underlying the dimension of reflection-impulsivity: the process of visual feature analysis. It was generally hypothesized that reflective and impulsive children differ in the extent to which they engage in detailed feature analyses of visual stimuli and stimulus arrays.

STUDY 1: KILBURG AND SIEGEL (1973)

It was postulated that the underlying basis for R-I differences is the differential extent to which reflective and impulsive children engage in the process of detailed visual feature analysis. It was argued that the Selfridge-Neisser "Pandemonium" model of pattern recognition (Neisser, 1966; Selfridge, 1959; Selfridge & Neisser, 1960) is heuristically useful in accounting for and predicting many of the performance differences between reflective

and impulsive children. The Selfridge-Neisser model is hierarchical and is based on a computer program for letter recognition which emphasizes feature testing. The model assumes that there are several levels of mechanisms operating on incoming information. Level 1 mechanisms are stimulus samplers that get basic information into the system; Level 2 mechanisms are stimulus analyzers, each of which determines whether or not (i.e., the extent to which) the stimulus is characterized by certain features. Results of these feature tests are conveyed to the next level, a set of "subroutines" which perform operations on the results of the feature tests. At the highest level, the probability values from these subroutines are compared and the item associated with the largest value is selected as the best "guess" as to the identity of the stimulus. Another feature of the model is that tests at the same level may be carried out simultaneously. Thus, the time required to "categorize" a stimulus at any given level does not depend directly on the number of feature tests performed, and a longer response latency might well reflect a difference in depth of the feature analysis performed (i.e., the degree to which the subject tends to do a "fine-grained" feature analysis).

On the basis of the model, we hypothesized that the differences between reflective and impulsive children were due to the tendency of reflective children to perform a more detailed and thorough feature analysis (Level 2). Impulsive performance might entail fewer stimulus samples drawn by Level 1 mechanisms; however, Drake's (1970), Siegelman's (1969), and Zelniker et al.'s (1972) data argue against this insofar as they looked at the stimuli an equivalent number of times. Rather, impulsive performance would more likely result in fewer features of the stimulus being tested on each "engagement" and, consequently, the impulsive child's decision would be made on the basis of a relatively poorly defined alternative.

The specific purpose of this initial study was to demonstrate that reflective and impulsive children differ in their tendency to perform a detailed visual feature analysis, as measured by their performance on a

forced-choice recognition memory task in which feature differences were manipulated.

Method

Subjects

Subjects consisted of 170 white males--74 first graders and 96 fifth graders--who were individually administered the MFF. As mentioned previously, the MFF is a match-to-sample task in which the subject is shown a standard stimulus and told to choose the one of six variants that exactly matches the standard. Two practice and ten test items were given. For each of the ten test items, the experimenter recorded the number of errors the child made (a maximum of three errors was allowed) and the response latency (time from stimulus presentation to first response, whether correct or not). For each age level, children whose mean response latency was above the median and whose total number of errors was below the median were classified as reflective; children whose mean response latency was below the median and whose total number of errors was above the median were classified as impulsive. Of the 74 first graders, 24 were classified as reflective and 22 as impulsive; of the 96 fifth graders, 35 were classified as reflective and 30 as impulsive. Correlations between MFF errors and mean MFF latency were highly significant for both first and fifth graders (r = -.54 and r = -.50, respectively; $p < .001$). The magnitude of this correlation closely approximates that found by Kagan et al. (1964) for children of similar age levels.

Stimulus and Apparatus

Due to time constraints, it was not possible to test all of the reflective and impulsive children on the recognition memory task. Thus, 18 children were randomly selected from each Grade x R-I subgroup. In a second session held approximately two weeks later, these 72 children were

individually administered the test of recognition memory. Stimuli for the recognition memory task consisted of a presentation deck and a test deck. The presentation deck consisted of 80 3 x 5-inch (7.62 x 12.7 cm) laminated white cards, on each of which was a black line drawing of a common object or animal. Each subject was handed the presentation deck and was told to look carefully at each of the cards and to go through the deck as quickly as he could.

Stimuli for the recognition test proper were 80 5- x 8-inch (12.7 x 20.32 cm) laminated white cards, on each of which were two black line drawings. The apparatus consisted of a test stand on which each of the test cards was placed. At the bottom of the stand was a photocell-controlled microswitch, wired to a Hunter timer (facing the experimenter), that started each time a new card was placed on the stand and stopped when the subject depressed one of two response buttons located beneath the stimulus loci. Following the initial presentation task, each subject was told that he would be shown some more cards with two drawings on them, and that for each card he was to look at both drawings and push the button underneath the one he had seen before in the first part of the game. Each subject was then shown all 80 test cards, one at a time. For each test card, the experimenter recorded whether the response was correct or incorrect and the latency of the response. The recognition test deck consisted of 80 cards, 20 from each of four experimental conditions. All children saw the 80 test stimuli in the same completely randomized order. Examples of presentation and recognition test items for each experimental condition are presented in Figure 1.

Experimental Conditions

Condition DO (Different Object). Twenty stimuli were chosen randomly from the 80 presentation stimuli, and each was paired with a completely new animal or object on the test card. This condition should

Figure 1. Examples of presentation stimuli and recognition test items for each of the experimental conditions. (From "Differential Feature Analysis of Reflective and Impulsive Children" by R. R. Kilburg & A. W. Siegel, Memory and Cognition, 1973, 1, 413-419. Copyright 1973 by The Psychonomic Society, Inc. Reprinted by permission.)

Page 12 (Fig. 1) removed due to copyright restrictions.

produce the most correct recognition since a correct response can be made either on a global feature analysis and/or on the basis of the name of the stimulus. Since Rosinski (1970) had found that the recognition performance of fifth graders was superior to that of first graders under a similar stimulus condition, it was expected that fifth graders would make more correct recognitions on these stimuli as well. Since a detailed visual feature analysis was not required in order to make a correct response, and since it was hypothesized that reflective and impulsive children differ primarily in their tendency to perform detailed feature analyses, the performance of the reflective and impulsive children was not expected to differ in this condition.

Condition 1FD (One Feature Difference). Twenty different stimuli from the original presentation stimuli were each paired with another stimulus having the same name, drawn in the same style, but differing from the original stimulus in only one minor feature. This condition should be the most difficult, since choosing the correct stimulus requires a rather complete feature analysis of the original stimulus during initial presentation, and since the correct choice cannot be made on the basis of the name of the stimulus. If these stimuli are not so difficult as to produce chance performance, then reflective children should make more correct recognition responses than impulsive subjects in this condition.

Condition MFD (Multiple Feature Differences). Twenty different stimuli from the original presentation stimuli were paired with another stimulus having the same name but drawn in a very different style and differing from the original stimulus in several different details. The MFD stimuli should be easier to discriminate than the 1FD stimuli since there are more feature differences between the correct and the incorrect stimulus. If the role of verbal labels is an important one in picture recognition memory, then MFD should produce fewer correct responses than DO since the correct choice cannot be made on the basis of the name of the stimulus. If the role of verbal labels is minimal, then, since the MFD stimuli differ

in a large number of visual features, they should produce approximately the same number of correct recognition responses as the DO stimuli. As in Condition 1FD, reflective subjects should make more correct recognition responses than impulsive subjects in this condition.

Condition DS/DO (Different Standard/Different Object). The remaining 20 stimuli from the presentation set were redrawn in a similar fashion as the MFD stimuli and were each paired with a completely new animal or object on the test card. This condition was included to see how children's recognition memory functioned for stimuli that they had never actually seen before but for which they might have either a global template or name from the presentation task. If, as Neisser (1966), Rosinski (1970), and Shepard (1967) have argued, recognition memory is primarily a visual process, then performance in this condition should be relatively poor, perhaps not greater than chance level. A correct recognition response can be made only on the basis of the name of the stimulus (or global template), not on the basis of specific visual features or details. Thus, the performance of reflective and impulsive subjects was not expected to differ in this condition.

It should be noted that differences in the performance of reflective and impulsive children were predicted only in the two conditions in which a correct recognition could be made solely on the basis of different visual features (1FD and MFD) and not in the conditions in which the correct response could be made on the basis of the name of the stimulus. If, as Kagan (1966a) has argued, a child's tendency to long or short response times (conceptual tempo) is consistent across a variety of perceptual (visual) tasks, response latencies of reflective subjects should be significantly greater than those of impulsive subjects.

Results

The means and standard deviations of the number of correct responses made under each of the four experimental conditions by each grade level and

R-I subgroup are presented in Table 1. Performance in each of the four conditions was consistently ranked in the same order for the entire sample and for both grade levels and R-I subgroups (from best to worst): DO, MFD, DS/DO, 1FD. This ordering is essentially in line with the predictions and is consistent across grade level and cognitive style. The mean performance of subjects in condition DO (73% correct) did not differ from that in condition MFD (69%), nor did performance in DS/DO (55%) differ from that in 1FD (51%). As predicted, however, performance in both DO and MFD was much greater ($p < .01$) than that in both 1FD and DS/DO.

Table 1

Means and Standard Deviations of the Number of Correct Recognition Responses for Each Grade Level and R-I Subgroup in Each of the Four Experimental Conditions

		Experimental Condition							
		DO		1FD		MFD		DS/DO	
	N	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Reflective	36	14.94	2.22	10.06	2.11	14.42	2.37	11.17	2.27
Impulsive	36	14.25	2.37	10.17	2.25	13.31	2.40	10.92	2.47
First Graders	36	14.00	2.31	9.86	2.62	13.48	2.50	10.97	2.75
Fifth Graders	36	15.19	2.18	10.36	1.58	14.25	2.33	11.11	1.92
Total	72	14.60	2.31	10.11	2.16	13.86	2.43	11.04	2.36

Note. Adapted from Kilburg and Siegel, 1973, p. 417.

Reflective subjects performed better ($p < .01$) than impulsive subjects in condition MFD only. Condition 1FD appeared to require a feature analysis too detailed for any of the children and, thus, a "floor" effect was obtained. Correct recognition in MFD could be made only on the basis of visual features: correct recognition in DO could be made on the basis of either visual features or the name of the stimulus; and correct recognition in DS/DO could be made only on the basis of the name of the stimulus. That performance in MFD was equivalent to that in DO and performance in both of these was greater than in DS/DO (which was nearly at chance) provides strong inferential evidence that recognition memory is primarily a process of visual feature analysis for both reflective and impulsive subjects--the role of "verbal mediation" seems to be minimal. Although fifth graders made more correct recognition responses in all conditions, this difference was significant only in DO ($p < .05$)--the "standard" recognition memory task. Thus, the capacity to perform visual feature analyses seems not to increase between first and fifth grade.

Mean latency of correct responses was consistently ordered for the entire sample and for each grade level and R-I subgroup (from fastest to slowest): DO, MFD, DS/DO, 1FD, thus mirroring the ordering for correct responses. The easier a given condition (i.e., the more correct responses), the shorter the response latency found. The mean latency in DO did not differ from that in MFD, nor did the latency in DS/DO differ from that in 1FD. However, the mean latencies in both DO and MFD were shorter ($p < .01$) than those in both DS/DO and 1FD. The overall mean latency of the impulsive subjects (3.36 seconds) was shorter ($p < .01$) than that of reflective subjects (3.83) and that of the first graders (3.34) was shorter ($p < .01$) than that of the fifth graders (3.85).

Discussion

Performance differences were found between reflective and impulsive children on a task requiring visual feature analyses and are congruent with

the findings of Drake (1970), Siegelman (1969) and Zelniker et al. (1972). However, it also seems clear that the data argue against the hypothesis that the nature of the search process is qualitatively different for reflective and impulsive subjects. Rather, reflective subjects seem to engage in a more thorough feature analysis of the stimuli. That the relative ordering of performance in the four conditions was similar for both reflective and impulsive subjects and that in all conditions the performance of reflective and impulsive subjects was greater (but not significantly so) seem to substantiate this reasoning. It would appear that in a task in which the only basis for correct recognition is that of visual features, reflective subjects tend to perform a more detailed feature analysis. The conclusions are congruent with Ault et al.'s (1972) finding that reflective and impulsive subjects used the same basic strategy of making comparisons between the standard and one variant (or between two variants), but reflective subjects made a greater proportion of these comparisons.

In particular, the results obtained in condition MFD are interpretable within the framework of the Selfridge-Neisser feature testing model of recognition. Both reflective and impulsive subjects tended to utilize the same feature analysis process, but reflective subjects tended to do a more thorough job. Although the experimental design used was insufficient to directly specify the level in the model at which these performance differences occur, the results were sufficiently promising to warrant further systematic recognition memory research within the framework of the Selfridge-Neisser model.

A third implication of this study is that since MFF items cannot be correctly solved on the basis of the name of the stimulus, the tendency to perform detailed visual feature analysis is perhaps the most significant component of the cognitive-perceptual basis underlying the dimension of reflection-impulsivity.

STUDY 2: SIEGEL, KIRASIC, AND KILBURG (1973)

The specific purpose of this study was to determine the feasibility of extending the paradigm to research with younger children and to determine the extent to which Kilburg and Siegel's (1973) results were generalizable to children at a younger developmental level and from a different socioeconomic background.

Method

Twenty-four black children (mean age = 5 years, range = 4-8 to 5-4) attending an experimental inner-city preschool were individually administered the Kansas Reflection-Impulsivity Scale for Preschoolers (KRISP). The KRISP (Wright, 1971) was used to determine R-I classification because (a) it had been developed specifically for use with children of preschool age, and (b) pilot testing indicated that even the simplest version of the MFF was too difficult and frustrating for these children. The KRISP is based on the MFF, but the five easier warmup items and the ten test items require less difficult discriminations and consist of much grosser feature differences than do the MFF items. Children whose mean response latency was above the median and whose total number of errors was below the median were classified as reflective; children whose mean response latency was below the median and whose total number of errors was above the median were classified as impulsive. A total of 11 children were classified as reflective (5 girls, 6 boys) and 10 were classified as impulsive (5 girls, 5 boys). The correlation between KRISP errors and mean KRISP latency ($r = -.53$, $p < .01$) is of the same magnitude as that found in the KRISP standardization data (Wright, 1971) and in much of the research done with the MFF (Kagan, 1966a). This would seem to indicate that the KRISP is an adequate instrument to assess R-I in preschool children.

In a second session held a week later, these 21 children were individually administered the test of recognition memory. The same stimuli,

experimental conditions, and procedures were used as in Study 1, with but two exceptions. First, the instructions for the presentation task were "to look carefully at each of these cards and go through the deck." (The additional instruction, "as quickly as you can," was omitted.) Second, the presentation apparatus was not utilized during the recognition test; instead, cards were shown manually to the child and response latency was not recorded. Five children (three reflectives, two impulsives) showed such marked position bias on the test of recognition memory (on the last 40 cards these children chose either the left or the right figure on all 40) that their data were excluded from further consideration.

Results

The means and standard deviations of the number of correct responses made in each condition by reflective and impulsive children are presented in Table 2. Reflective children made more correct responses (56.63) than did the impulsive children (50.63; $p < .05$). As Kilburg and Siegel had found (1973), there was a highly significant effect ($p < .001$) of experimental conditions.

Table 2

Means and Standard Deviations of the Number of Correct Recognition Responses for Reflective and Impulsive Preschoolers in Each of the Four Experimental Conditions

		Experimental Condition							
		DO		1FD		MFD		DS/DO	
Group	*N*	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Reflective	8	15.75	1.58	12.13	2.90	13.88	2.70	14.88	1.89
Impulsive	8	14.63	2.26	10.25	2.71	12.63	3.20	13.13	1.46
Total	16	15.19	1.97	11.19	2.88	13.25	2.93	14.00	1.86

Note. Adapted from Siegel, Kirasic, and Kilburg, 1973, p. 655.

As can be seen from Table 2, performances for both reflective and impulsive children were ordered (from best to worst): DO, DS/DO, MFD, 1FD. Performance in DO (76% correct) and DS/DO (70%) was greater ($p < .05$) than that in 1FD (56%), but not greater than in MFD (66%). As is clear from Table 2, reflective children made more correct responses than did impulsives in all four experimental conditions.

To determine whether or not the reflective children showed superior performance across all items, the ten easiest and the ten most difficult items within each condition (determined empirically on the basis of research with older children) were summed over the four conditions. The performance of the reflective children on the easy items (31.38/40 or 78% correct) was not significantly greater than that of the impulsive children (29.25/40 or 73%). On the other hand, the performance of the reflective children on the difficult items was significantly ($p < .01$) greater (25.25/40 or 63%) than that of the impulsive children (21.25/40 or 53%). The performance of the reflective children on the difficult items was significantly greater than chance ($p < .025$), whereas that of the impulsive children was not.

Discussion

Reflective children performed better on the test of recognition memory than did impulsive children, and this difference in performance was more or less constant across all four experimental conditions. These results indicate that, although both reflective and impulsive children can utilize feature differences in problem solution, reflective children tend to perform a more thorough and detailed feature analysis of the stimulus array. This reasoning is substantiated by the finding that whereas reflective and impulsive children did not differ on the easy items within each condition, reflectives recognized more of the difficult items (which, at least in conditions 1FD and MFD, required a more detailed feature analysis).

Performance was consistently highest in the two conditions in which successful performance could be achieved by labeling the stimuli during original presentation (DO and DS/DO). Thus Kilburg and Siegel's (1973) conclusion that picture recognition memory is a purely visual process is not totally accurate. It will be remembered that the children in this study were preschoolers enrolled in an inner-city experimental preschool. In this program (and in a variety of other preschool programs which, intentionally or not, emphasize "pre-reading" skills), considerable emphasis is placed on the child's acquiring a vocabulary. One of the most common teaching strategies in the acquisition of a vocabulary, in general and in this particular setting, employs the pointing at and "labeling" of things by both the teacher and the child. That is, it is not unreasonable to assume that these preschoolers' experience in the classroom predisposes them to spontaneously label objects presented to them in a wide variety of situations. (It is not necessary to assume that the label produced mediates performance [Flavell, 1970].) On the other hand, Kilburg and Siegel's (1973) first graders (mean age = 7 years, 2 months) came from school situations in which, by the end of first grade, teaching emphasis is placed not on labeling concrete objects, but rather on relationships, stringing words together to form sentences, reading per se, and the use of more abstract words. From the present data, it appears that verbal labeling (which may well facilitate feature analysis) was in some measure responsible for successful recognition performance in these preschoolers. However, since performance in condition 1FD was a bit better than chance and performance in MFD was well above chance, visual feature analysis independent of verbal processes also contributes significantly to correct recognition performance.

Although it seems intuitively likely that verbal labels should enhance recognition performance, it is quite likely that their role is an indirect one: A label likely serves to increase the probability of a feature analysis (Lynch, 1972). If it is assumed that (a) the capacity to perform visual feature analysis is relatively constant across the preschool-elementary years, and

(b) preschoolers tend (more than first graders or older children) to spontaneously label stimuli (pictures) presented to them, then verbally labeling the presentation stimuli should differentially facil tate performance on stimuli which can only be recognized on the basis of the name of the stimulus.

Relative to this point, it is of interest to compare the present results to those obtained by Kilburg and Siegel's (1973) first graders. As can be seen from Tables 1 and 2, the preschoolers' performance compares quite favorably with that of the first (and fifth) graders. Post hoc analyses indicated that the performance of these two populations did not differ significantly on conditions DO, MFD, and 1FD, but the performance of preschoolers was significantly greater ($p < .001$) than that of first graders on condition DS/DO. Although the absolute level of recognition memory was not very high in 1FD for either population, the preschoolers' performance was significantly greater than chance, whereas that of the first graders was not. There is a temptation to attribute the difference to the change of instructions in the present study. The words "as quickly as you can" were not included in the instructions given to the preschoolers. In fact, preschoolers did take longer on the average to go through the initial presentation deck than did the first graders. However, the difference in the average exposure time per stimulus was only 1.6 seconds (3.60 vs. 2.00). It was the authors' observation that most of this 1.6 seconds was due to the preschoolers taking longer to manipulate the card and put it face down in the pile. If the instructional difference had produced a really "powerful effect," then the rather striking superiority of the preschoolers' performance on DS/DO should have been found in the other three conditions (especially DO). Thus, it seems reasonable to assume that the superior performance of the preschoolers on DS/DO was due primarily to their greater tendency to label each stimulus on presentation, and that these labels facilitated picture recognition memory in the condition in which stimuli could be recognized only on the basis of the name of the stimulus.

In summarizing the results of the first two studies, it should be pointed out that previous recognition memory research with children has found that recognition memory is enhanced when any kind of specific orienting response to the presentation stimulus is required by the child. A verbal label or an instruction to point to a distinctive feature may well be "attentional" in effect (Lynch, 1972). Thus, a label would serve to increase the probability of a thorough feature analysis. Since KRISP and MFF items cannot be correctly solved on the basis of verbal labels (e.g., the standard and all six variants are "teddy bears"), the data from these two studies indicate that the tendency to perform detailed visual feature analysis is a significant component of the cognitive-perceptual basis underlying the dimension of reflection-impulsivity.

STUDY 3: SIEGEL, BABICH, AND KIRASIC (1974)

Certain methodological problems in Study 2 (Kilburg & Siegel, 1973) precluded adequate testing of the hypothesis (derived from the Selfridge-Neisser model) that reflective children perform a more detailed and thorough feature analysis than do impulsive children. Due to ambiguous instructions during the initial presentation of the later-to-be-recognized stimuli, performance on items in which the correct and incorrect test stimuli differed in only one visual feature was not significantly better than chance. More importantly, in the one condition in which a significant R-I difference was found, the number of feature differences between the correct and incorrect test stimuli was large (three to as many as seven or eight) and varied unsystematically.

Systematic manipulation of the number of feature differences between correct and incorrect test stimuli should provide a more rigorous test of the hypothesis: Reflective children should do better than impulsive children only when there are relatively few feature differences between correct and incorrect test stimuli. Moreover, since one criterion in deciding whether

an individual is reflective or impulsive is response latency, and since the Self-ridge-Neisser model can account for most of the choice reaction time data with adults (Smith, 1968), it was predicted that the expected R-I differences in correct responses would also be found in their response latencies.

Method

Ninety-four white, middle-class, fifth-grade boys were individually administered the MFF: 32 were classified as reflective and 31 as impulsive. In a second session held approximately two weeks later, these children were individually administered the test of recognition memory. The initial presentation deck consisted of 96 3- x 5-inch (7.62 x 12.7 cm) laminated white cards, on each of which was a black line drawing of a common object or animal. Each subject was told to look carefully at each of the cards and to go through the deck.

Stimuli for the recognition test were 96 5- x 8-inch (12.7 x 20.32 cm) laminated white cards, on each of which were two black line drawings. The apparatus described in Study 1 was used to present the cards and measure response latency. Each subject was shown all 96 test cards, one at a time. For each test card, the experimenter recorded whether the response was correct or incorrect and the latency of that response. All subjects saw the 96 test stimuli in the same, completely randomized, order.

The recognition test deck consisted of 96 cards, 24 for each of four experimental conditions. Examples of presentation and recognition test items for each of the four experimental conditions are presented in Figure 2.

Condition DO (Different Object). Twenty-four stimuli were randomly chosen from the 96 presentation stimuli and each was paired with a completely different object or animal on the test card. Since the correct and incorrect test stimuli had different names and also differed in an indefinitely large number of visual features, this condition should produce a

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Figure 2. Examples of presentation stimuli and recognition test items. (From "Visual Recognition Memory in Reflective and Impulsive Children" by A. W. Siegel, J. M Babich, & K. C. Kirasic, Memory and Cognition, 1974, 2, 379-384. Copyright 1974 by The Psychonomic Society, Inc. Reprinted by permission.)

very high level of correct recognition performance. Since it was hypothesized that reflective and impulsive subjects differ primarily in their tendency to perform detailed feature analyses, and since a detailed visual feature analysis was not required to make a correct response to these stimuli, no performance differences between reflective and impulsive subjects were expected in this condition. Additionally, Kilburg and Siegel (1973) had found no R-I differences in an identical condition.

Condition 1FD (One Feature Difference). Twenty-four different presentation stimuli were each paired with another stimulus having the same name, but differing from the original stimuli in one visual detail or feature.

Condition 2FD (Two Feature Differences). Twenty-four different presentation stimuli were each paired with another stimulus having the same name, but differing from the original stimuli in two visual details. (It should be obvious from Figure 2 that we do not have an "objective" feature-counting system. It could be argued that in attempting to vary only the front of the sled in condition 1FD, we objectively varied several discrete features. It could be argued that in attempting to vary only the whiskers and the curve of the cat's tail in condition 2FD, we objectively varied placement of tip of tail relative to the cat's back, curvature of the tail, and six whiskers. Finally, it could be argued that in attempting to vary the four features of number of propellers, shape of wing, orientation, and nose of plane, we in fact varied an almost infinite number of feature differences. Thus, the feature-counting system was subjective and represents, at best, an attempt to systematize feature differences along an ordinal scale.)

These two conditions (1FD and 2FD) should be the most difficult since choosing the correct stimulus requires a rather complete visual feature analysis of the original stimulus during initial presentation. Performance in condition 1FD should be poorer than that in 2FD, and performance in both should be poorer than in DO. However, in both conditions 1FD and 2FD, reflective subjects should make more correct responses than impulsive subjects.

Condition 4FD (Four Feature Differences). The remaining 24 presentation stimuli were each paired with another stimulus having the same name, but differing from the original stimulus in four visual details or features. Kilburg and Siegel (1973) found that reflective subjects made more correct responses than impulsive subjects in a similar condition, but a large and variable number of features had distinguished the correct from the incorrect test stimuli. Thus, it was not clear that the R-I difference would be significant when the number of feature differences was large (i.e., four) and constant. Performance in this condition should be better than that in 1FD and 2FD. If recognition memory is determined by a process of visual feature analysis (independent of verbal labeling), then performance in condition 4FD should be equivalent to that in DO.

In short, reflective and impulsive subjects were predicted to differ in conditions where detailed visual feature analyses were required for correct recognition but not in conditions where a more global feature analysis would suffice (i.e., DO and probably 4FD). Generally, it was expected that the greater the number of feature differences between correct and incorrect test stimuli, the better would be the recognition memory performance.

It was also expected that mean correct response latency would be related to the number of correct responses. Specifically, latencies should be longest in condition 1FD, next longest in 2FD, and shorter in both DO and 4FD. As was expected for the correct response data, an interaction of R-I and condition was expected for the correct response latency data.

Results

Correct responses. The means and standard deviations of the number of correct responses made in each of the four experimental conditions by reflective and impulsive subjects are presented in Table 3. Reflective subjects made more ($p < .01$) total correct responses (81.83) than did impulsive subjects (77.24). Conditions differed significantly among each

other ($p < .001$). As predicted, performance in condition DO (22.05) did not differ from that in 4FD (22.22), and performance in both DO and 4FD was greater ($p < .05$) than that in both 2FD (17.97) and 1FD (17.30).

Table 3

Means and Standard Deviations for Reflective and Impulsive Subjects: Number of Correct Responses and Latencies for Each Experimental Condition

	Experimental Condition							
	DO		1FD		2FD		4FD	
Group	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Correct Responses								
Reflectives (N = 29)	22.59	1.57	18.28	1.94	18.24	2.17	22.72	1.19
Impulsives (N = 29)	21.52	2.41	16.31	2.30	17.69	2.25	21.27	1.75
All Subjects (N = 58)	22.05	2.09	17.30	2.33	17.97	2.21	22.22	1.57
Latencies								
Reflectives (N = 29)	2.46	1.14	3.15	1.34	2.74	.96	2.26	.79
Impulsives (N = 29)	2.18	.66	2.71	.83	2.32	.65	2.16	.67
All Subjects (N = 58)	2.32	.93	2.93	1.13	2.53	.84	2.21	.73

Note. Adapted from Siegel, Babich, and Kirasic, 1974, p. 382.

Contrary to prediction, performance in 2FD (75% correct) was not significantly greater than that in 1FD (73%), but the difference was in the predicted direction. That performance in DO (93%) and 4FD (92%) was equivalent and that a correct response in 4FD could not be made on the basis of the name of

the stimulus (e.g., both correct and incorrect test stimuli are airplanes) provides strong inferential evidence that visual recognition memory is determined by a process of visual feature analysis, and that verbal labels have little or no direct effect on visual recognition performance.

The predicted interaction of R-I and condition was only marginally significant ($p < .08$). Reflective subjects made more correct responses only in condition 1FD ($p < .05$). This finding was crucial to, but only partially confirmed, the hypothesis (reflective and impulsive subjects did not differ in 2FD). As predicted, reflective and impulsive subjects did not differ in condition DO.

The differential performance of reflective and impulsive subjects in conditions in which correct and incorrect test stimuli were distinguished only by visual features was predicted from the Selfridge-Neisser feature-testing model. So, an additional repeated measures analysis was performed on the number of correct responses by each subject in the three "FD" conditions (1FD, 2FD, 4FD). Reflective subjects made significantly more ($p < .01$) correct responses in these three conditions (59.24) than did impulsive subjects (55.72). The conditions effect was highly significant ($p < .001$): Performance in conditions 1FD and 2FD was equivalent and significantly poorer than in 4FD. Most importantly, the interaction of R-I and condition was significant ($p < .05$). For reflective subjects, performance in 1FD and 2FD was equivalent and poorer than in 4FD; for impulsive subjects, performance in 1FD was poorer than in 2FD, and that in 2FD was poorer than in 4FD.

Correct response latencies. The means and standard deviations of the latencies of correct responses of reflective and impulsive subjects in each of the four experimental conditions are also presented in Table 3. The mean latency in condition 1FD (2.93 seconds) was significantly longer ($p < .01$) than that in 2FD (2.53). Mean latencies in 1FD and 2FD were significantly longer ($p < .01$) than those in 4FD (2.21) and DO (2.32); those in 4FD and DO did not differ significantly ($p > .10$).

Page 30 (Fig. 3) removed due to copyright restrictions.
Figure 3. Mean leatency of correct responses. (From "Visual Recognition Memory in Reflective and Impulsive Children" by A. W. Siegel, J.M. Babick, & K.C.Kirasic, Memory and Cognition, 1974,2,379-384. Copyright 1974 by The Psychonomic Society, Inc.

For reflective subjects, the mean latencies in all three conditions were significantly different from each other. For impulsive subjects, latency in 1FD was longer than that in 2FD and 4FD, but latency in 2FD was not significantly longer than in 4FD.

Discussion

In general, the results of the present study are congruent with earlier research (e.g., Drake, 1970; Kilburg & Siegel, 1973; Odom et al., 1971; Zelniker et al., 1972) in that performance differences between reflective and impulsive children were found on a task requiring visual feature analyses.

Although the performance of reflective subjects was superior to that of impulsive subjects in all conditions, this difference was significant only in condition 1FD. This finding supports the hypothesis that performance differences between reflective and impulsive children are greatest when a very detailed feature analysis is required. Moreover, since each of the MFF variants differ from the standard in only one visual feature, the finding of a R-I performance difference only in condition 1FD takes on added significance. That is, from these data it can be argued that underlying basis for the R-I dimension is quantitative rather than qualitative; reflective-impulsive performance differences reflect a difference in the extent to which subjects perform a detailed visual analysis of the stimulus array, rather than reflecting a broad cognitive disposition. Reflective-impulsive differences can be specified, to a large extent, by a feature-analytic model of pattern recognition.

That performance in conditions 4FD and DO was equivalent further confirms our hypothesis. Although a stimulus could be correctly recognized (possibly) on the basis of the name of the stimulus in DO, a correct response in 4FD could not since both correct and incorrect stimuli had the same names. Thus, again, strong inferential evidence is provided that correct recognition in both conditions is primarily dependent on visual

processes and is relatively independent of verbal processes. That the pattern of correct response latencies paralleled that of correct responses further supports this contention.

Indeed, the response latency from the "FD" conditions provides the strongest confirmation of the applicability of the Selfridge-Neisser model to R-I performance differences and recognition memory. Correct response latency was inversely related to the number of feature differences between correct and incorrect test stimuli (Figure 3). The greater the number of feature differences between the correct and incorrect test stimuli, the shorter the latency of correct responses. When there was only one feature difference between the correct and incorrect test stimuli, a very detailed feature analysis had to be performed during initial presentation, and a large number of feature tests had to be made during the test itself in order to make a correct response; the more (and fine-grained) tests that had to be performed, the longer the corresponding latency should be. That response latency in DO and 4FD was equivalent is congruent with the Selfridge-Neisser model because the model allows feature tests at the same level (i.e., of detail) to be carried out simultaneously. Our data indicate that this is the case when there are a large number of feature differences. As can be seen from Figure 3, the time taken for several feature tests to be performed quickly reaches an asymptote at about four features.

STUDY 4: KIRASIC AND SIEGEL (in press)

In both Studies 1 and 3, subjects were allowed to go through the presentation deck at their own pace. Reflective subjects took longer to do this than did impulsive subjects. Although this difference was minimal (a mean difference of about .25 seconds/card), the possibility remains that reflective subjects did better than impulsive subjects because they were exposed to each stimulus for a longer period of time, thus permitting either more or more detailed feature tests to be performed. A test of this hypothesis requires a systematic manipulation of exposure time.

Study 4 represents an attempt to investigate the effect of exposure time on the recognition memory performance of adults who have been identified as reflective and impulsive. Rather than selecting two arbitrary exposure times, separate groups of reflective and impulsive subjects were tested first. The average time taken to go through the presentation stimuli was divided by the number of items for the reflective and impulsive subjects, respectively, and this determined the exposure times for a second group of reflective and impulsive subjects. The second group of reflective subjects were then shown the presentation stimuli for the same amount of time as the first group of impulsive subjects; similarly, the second group of impulsive subjects were shown the presentation stimuli for the same amount of time as the first group of reflectives. If performance in the various conditions is not markedly affected by a large difference in initial exposure time, this will provide additional evidence that R-I differences occur at Level 2 (feature testing) of the Selfridge-Neisser feature testing model rather than at Level 1 (gross stimulus sampling).

As had been found before in Studies 1 and 3, the overall performance of reflective subjects was predicted to be superior to that of impulsive subjects. Most importantly, an interaction was predicted between R-I and the four experimental conditions (DO, 1FD, 2FD, and 4FD): Reflective and impulsive subjects should differ only in conditions in which detailed visual feature analyses are required (conditions 1FD and 2FD), but not in conditions where a more global feature analysis would suffice to produce a correct response (conditions 4FD and DO). Generally, the more detailed a feature analysis required (i.e., the fewer features distinguishing the correct and incorrect stimuli), the greater should be the advantage of the reflective subjects: The difference should be greatest in 1FD, next greatest in 2FD, and least in 4FD and DO.

On the basis of the Selfridge-Neisser feature testing model, it was generally expected that the greater the number of feature differences between

correct and incorrect test stimuli, the better would be performance. As had been found by Siegel et al., (1974), it was expected that performance in conditions 4FD and DO would be equivalent and superior to that in 1FD and 2FD. Latencies for correct responses should be longest in condition 1FD, next longest in 2FD, and shorter in both DO and 4FD. (The latter two should not differ.)

Method

Sixty five college students, 36 females and 29 males (mean chronological age = 20 years), participated in the research on a volunteer basis. The MFF (8-variant version) was individually administered to all 65 subjects during a first session; 22 were classified as reflective and 22 as impulsive. Subjects whose scores fell at either median were excluded.

In a second session held approximately one week later, 11 reflective and 11 impulsive subjects were randomly selected (approximately equal number of males and females in each group) and administered the recognition memory task. Stimuli, apparatus, procedures, and experimental conditions were identical to those of Study 3. Each subject was allowed to go through the entire presentation deck at his or her own pace. The total amount of time the subject took to go through the deck (i.e., to look at all 96 stimuli) was recorded. The mean time taken to go through the presentation deck was computed separately for the 11 reflective (776 seconds) and 11 impulsive (377 seconds) subjects. Dividing these means by 96 yielded the average time that each card was looked at: 7.98 seconds/card for reflective subjects; 3.93 seconds/card for impulsive subjects. These mean values were then used as the exposure times for the presentation of each of the 96 stimuli to the remaining 22 subjects.

The remaining 11 reflective and 11 impulsive subjects were then individually administered the recognition memory task. The procedures used were identical to those used for the first group with one important exception:

The 11 reflective subjects were shown the presentation stimuli at a rate of one stimulus/four seconds, and the 11 impulsive subjects were shown the stimuli at a rate of one stimulus/eight seconds. A silent Paquet metronome was used to time stimulus presentation.

Results

A 2 (R-I) x 2 (Exposure Time) x 11 (Subjects/cell) x 4 (Conditions) repeated measures analysis of variance was performed on the number of correct responses in each condition for each subject. As predicted, the main effect of R-I was highly significant, F (1, 40) = 60.88, $p < .0001$: Reflective subjects made significantly more total correct responses (91.32/96 or 95%) than did impulsive subjects (83.77/96 or 87%). The main effect of exposure time was not significant, $F < 1$; the R-I x Exposure Time interaction was highly significant, F (1, 40) = 16.34, $p < .0001$. However, since this interaction represents pooled performance over four experimental conditions, and since we were interested in R-I differences in the individual conditions, the R-I x Exposure Time interaction on overall performance is of little theoretical interest.

The main effect of condition was, as expected, highly significant F (3, 120) = 49.16, $p < .0001$. Scheffé (.01) confidence intervals (MSE = 1.98, CV = 1.03) indicated that, as predicted, performance in conditions DO and 4FD (96% and 97%, respectively) was equivalent. Performance in both DO and 4FD was significantly better than in either condition 1FD or 2FD (both 86%). That performance in DO and 4FD was equivalent and that a correct response in 4FD could not be made on the basis of the name of the stimulus (e.g., both correct and incorrect test stimuli were airplanes) provides, once again, strong inferential evidence that visual recognition memory is determined by a process of visual feature analysis, and that verbal labels have little or no direct effect on visual recognition performance.

Finally, as predicted, the R-I x Condition interaction was highly significant, F (3, 120) = 6.09, $p < .01$. The means and standard deviations of the number of correct responses made in each of the four experimental conditions by reflective and impulsive subjects are presented in Table 4.

Table 4

Means and Standard Deviations of the Number of Correct Responses for Reflective and Impulsive Subjects in Each of the Experimental Conditions

	Condition							
	DO		1FD		2FD		4FD	
Group	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Reflectives (N = 22)	23.68	.54	22.09	1.45	21.86	1.16	23.68	.62
Impulsives (N = 22)	22.41	1.66	19.05	1.44	19.41	2.06	22.91	.82
All Subjects (N = 44)	23.05	1.23	20.57	1.45	20.64	1.67	23.30	.73

Scheffé (.01) confidence intervals (MSE = 1.98, CV = 1.44) indicated that the pattern of results were similar for reflective and impulsive subjects: Performance on condition DO was equivalent to that on 4FD, and performance on both was significantly greater than that on 1FD and 2FD; performance on the latter two conditions did not differ significantly for either reflective or impulsive subjects. Comparisons between reflective and impulsive subjects on the same conditions, however, revealed the source of the interaction. The performance of reflective subjects was significantly greater than that of impulsive subjects only in conditions 1FD and 2Fd--the conditions

requiring the most detailed visual feature analyses in order to make a correct response. As predicted, for conditions in which only visual features (and not the name) differentiated correct and incorrect test stimuli (1FD, 2FD, 4FD), the superiority of the reflective subjects increased as the number of differentiating visual details increased. Whereas the difference between reflective and impulsive performance was only .77 correct responses in condition 4FD (a difference of 3%), the advantage increased to 2.45 correct responses in 2FD (10%) and increased even further to 3.04 correct responses in condition 1FD (13%). The R-I x Exposure Time x Condition interaction was not significant, $F < 1$, indicating that initial exposure time had no effect on the pattern of condition differences between reflective and impulsive subjects.

Each subject's mean latency for each of the four experimental conditions was computed on the basis of correct responses only. A 2 (R-I) x 2 (Exposure Time) x 11 (Subjects/cell) x 4 (Conditions) repeated measures analysis of variance was performed on these data. Only the main effect of condition was significant, $F(3, 120) = 59.59$, $p < .0001$. Scheffé (.01) confidence intervals (MSE = .200, CV = .32) indicated that the mean latency in condition 1FD (3.01 seconds) was significantly longer than that in 2FD (2.43). Mean latencies in both 1FD and 2FD were significantly longer than those in 4FD (1.89) and DO (1.94). Latencies in 4FD and DO were equivalent. Neither the main effect of R-I, nor exposure time, nor any interactions which included these variables were significant, all F's < 1.

Discussion

These results are congruent with earlier research with children (e.g., Drake, 1970; Kilburg & Siegel, 1973; Odom et al., 1971; Siegel et al., 1974; Zelniker et al., 1972): Performance differences between reflective and impulsive subjects were found on a task requiring visual feature analyses. Although the performance of reflective subjects was superior to that

of impulsive subjects in all conditions, the difference was significant only in conditions 1FD and 2FD--the conditions requiring the most detailed feature analyses. Since each of the MFF variants differs from the standard in only one visual feature, and since this instrument is used as the primary index for R-I classification, these data imply that the underlying basis for the dimension of reflection-impulsivity is a process of visual feature analysis rather than a broad cognitive disposition. Additionally, the finding of the predicted increase in the advantage of reflective subjects as the feature analysis required gets more fine-grained indicates that R-I performance differences can be specified within a feature-analytic model of pattern recognition.

The response latency data also provide confirmation of the applicability of the Selfridge-Neisser model to R-I performance differences in recognition memory. Correct response latency was inversely related to the number of feature differences between correct and incorrect test stimuli: When there was only one feature difference between the correct and incorrect test stimuli, a very detailed feature analysis had to be performed during initial presentation and a large number of feature tests had to be made during the test itself in order to make a correct response. Our data indicate that the time taken to correctly identify a stimulus asymptotes at about four feature differences (although these differences are not objectively defined), since the latency in DO (in which correct and incorrect stimuli differed in an infinite number of visual features) and 4FD were equivalent.

That both correct responses and latencies in 4FD and DO were equivalent confirms our previous research which indicates that correct recognition in both conditions is primarily dependent on visual processes and is relatively independent of verbal processes (at least for subjects in the age range tested). Although a correct recognition could perhaps be made on the basis of the name of the stimulus in DO, a correct response in 4FD could not since both correct and incorrect test stimuli had the same name.

Finally, the efficiency of visual recognition memory should be noted. Given no special instructions, the impulsive subjects correctly recognized 79% (19.05/24) of the stimuli even when the correct and incorrect test stimuli differed in only one distinctive feature. Performance under normal or "standard" recognition memory condition (condition DO) for all subjects was 96% (23.05), a figure in line with results from studies which have used as many as 600 (Shepard, 1967) or even 2500 highly differentiated pictorial stimuli (Standing, Conezio, & Haber, 1970). This level of performance is all the more remarkable in that the stimuli were black and white line drawings, whereas the stimuli used by Shepard (1967) and Standing et al. (1970) were colored pictures of real objects and scenes. That the process of recognition memory at exposure times of four and eight seconds is visual, and not verbal, can be inferred from the equally high performance of the sample as a whole in condition 4FD (97%).

In summary, the results from this experiment indicate that (a) reflective and impulsive adults differ in their propensity to engage in a detailed feature analysis of visual stimuli; (b) visual feature analysis seems to be a most significant component in the underlying basis of the dimension of R-I; (c) R-I performance differences can be conceptualized within the Selfridge-Neisser feature testing model of pattern recognition as occurring at Level 2 (feature testing) rather than at Level 1 (gross stimulus sampling); and (d) level of recognition performance is strongly influenced by the number of visual feature differences between correct and incorrect items.

COMPARISON OF THE RESULTS FROM THE FOUR STUDIES

To assess the effect of differential instructions on recognition memory performance, it is of interest to compare the performance of the fifth graders in Study 1 to that of the fifth graders in Study 3. The test stimuli in conditions DO and 1FD were identical. The instructions given to the subjects were slightly different, however. Kilburg and Siegel's (1973, Study 1)

instructions in the presentation task were "look carefully at each of the cards and go through the deck as quickly as you can." The instructions in Study 3 were "look carefully at each of the cards and go through the deck." The difference in performance of the two samples of fifth graders was strikingly different. As can be seen in Table 1, fifth graders tested under the "carefully and quickly" instructions correctly recognized only 76% (15.19/20) of the DO stimuli and 51% (10.36/20) of the 1FD stimuli. As can be seen in Table 3, fifth graders tested under the "carefully" instructions recognized 93% (22.05/24) of the DO stimuli, and 73% (17.30/24) of the 1FD stimuli. Thus, it is clear that absolute level of recognition memory for pictures can be influenced by task instruction as well as by variations in the nature of the relationship between correct and "decoy" stimuli.

To assess the extent to which recognition memory for line drawings changes with development, it is of interest to compare the performance of preschoolers (Study 2), fifth graders (Study 3), and adults (Study 4) in comparable conditions. Conditions DO and 1FD were constant across the three studies, and condition MFD in Study 2 was essentially equivalent to condition 4FD in Studies 3 and 4. All three samples were tested under identical instruction ". . . to go carefully. . . ." The relative performance of subjects at these three age levels is presented in Table 5. For purposes of statistical comparison, the mean number of correct responses possible in each condition (out of 20) and the standard deviations were adjusted upward proportionally to give an expected number of correct responses (out of 24 possible--the number possible in Studies 3 and 4).

Fifth graders made significantly more correct responses than did preschoolers, t (72) $\geq$ 4.23, $p < .001$, in all three conditions. The difference was greatest in condition 4(M)FD (27%), but also substantial in DO and 1FD (both 16%). Due to the extremely low variance associated with the means of the fifth graders and adults, the adults made significantly more correct responses than fifth graders in all three conditions. The

Table 5

Performance of Preschoolers, Fifth Graders, and Adults in Comparable Experimental Conditions: Mean Number Correct Responses, Standard Deviations, and Percent Correct

		Condition								
		DO			MFD/4FD			1FD		
Group	*N*	Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%
Preschoolers (Study 2)	18	18.22*	2.36*	76	15.90*	3.56*	66	13.41*	3.46*	56
Fifth Graders (Study 3)	58	22.05	2.09	92	22.22	1.57	93	17.30	2.33	72
Adults (Study 4)	44	23.05	1.23	96	23.30	.73	97	20.57	1.45	86

* Adjusted to basis of 24 possible correct responses

difference was greatest in condition 1FD (14%), $t\,(100) = 8.61$, $p < .001$, but was also highly significant in DO, $t\,(100) = 3.02$, $p < .005$, and in 4FD, $t\,(100) = 4.62$, $p < .001$, even though the percentage advantage was very small (4%). Thus, it appears that the tendency or capacity to perform detailed feature analyses of visual stimuli does increase over development. However, an increase of only 16% in almost any performance measure between the ages of five and ten years (or between ten years and adulthood) is hardly an impressive one. Many "abilities" such as conservation, double classification, understanding of passive tenses, and so on, undergo a

growth from 0% to 100% in the same period of time. That is, one cannot argue that a 16% performance increment in recognition memory performance indicates any significant qualitative or structural cognitive changes between five and ten years (much less that a 14% performance increment indicates any significant qualitative cognitive changes between ten years and adulthood). It is of interest to note, however, that whereas the preschoolers performed nearly at chance on the 1FD stimuli (56%), the performance of adults was 30% better! Clearly a difference of this magnitude does indicate a marked development in the capacity or tendency to perform detailed visual feature analyses between the preschool years and adulthood.

General Summary and Conclusions

The results from the experiments discussed indicate several important positive and intriguing tentative conclusions about the underlying perceptual-cognitive basis of the dimension of reflection-impulsivity and the process of recognition memory.

1. Reflective and impulsive children do differ in the extent to which they engage in a detailed visual feature analysis of stimulus arrays. As the discrimination between the correct and incorrect test stimuli becomes more difficult (i.e., as the number of visual features distinguishing the stimuli becomes smaller), the reflective children perform progressively better than impulsive children because they have performed a more detailed feature analysis of the presentation stimuli.

The Selfridge-Neisser model seems to be an appropriate framework for the conceptualization of R-I performance differences. Data from the first three studies indicated that the R-I differences occurred at Level 2 of the model (feature testing) rather than at Level 1 (gross stimulus sampling). The finding in Study 4, that exposure time had no effect on recognition memory performance, argues strongly for this position. Since there were no resultant performance differences as a result of whether the

stimuli were initially presented for four or eight seconds, it is unlikely that the .25-second differences in exposure time for each item (Study 3) would have had an effect either.

KRISP and MFF items constitute the primary index of R-I classification. In these items, each variant differs from the standard in only one small visual feature. Since KRISP and MFF items cannot be correctly solved on the basis of verbal labels, the extent to which detailed visual feature analyses are performed seems to be the most significant component in the underlying basis of the dimension of reflection-impulsivity.

2. The studies provide strong inferential evidence that picture recognition memory is primarily a process of visual feature analysis. Verbal labels, however, can enhance performance on items in which a correct response can only be made on the basis of the name of the stimulus. It is highly likely that the role of verbal labels in recognition memory is an indirect one in that the act of verbal labeling is one of a number of specific orienting responses that serve to increase the probability or amount of selective attention, and thus to increase the probability of a thorough feature analysis.

Our results clearly demonstrate the power of the visuo-spatial knowledge system in children and adults (see Siegel & White, in press). Findings from several of the studies indicate that recognition memory for pictures is predominantly a visual process of remarkable robustness. Recognition memory performance was generally very high, even under impoverished stimulus conditions (i.e., line drawings of stimuli as opposed to full-blooded pictures) and under test conditions in which the correct and incorrect test stimuli were only barely discriminable.

3. The overall level of recognition memory performance seems to be susceptible to differential instructions. In the studies discussed, instructions to look at the presentation stimuli carefully, without emphasis on speed,

significantly facilitated recognition memory performance. With instructions held constant, recognition memory for pictures (specifically, black and white line drawings) appears to increase over the elementary school years. The most marked indication of this appears when the correct and incorrect test stimuli differ in only one distinguishing feature: In order to make a correct response, the subject must have performed a detailed feature analysis of the presentation stimuli. Our findings corroborate both Kagan et al.'s (1964) findings that MFF performance, especially accuracy, increases with age, and findings of other researchers (e.g., Brown, 1973) that there is relatively little developmental change when the correct and incorrect test stimuli are different items (i.e., require only a global feature analysis).

4. Reflection-impulsivity aside, both the Selfridge-Neisser feature testing model of pattern recognition and the present experimental paradigm are promising vehicles for future research aimed at understanding the process of recognition memory. The experimental paradigm can be readily modified to include the presentation of a variety of more complex and "ecologically valid" static and dynamic stimuli without requiring a specific level of motor coordination or verbal sophistication in the subjects.

Despite the positive findings generated by the research, our results do suggest several caveats regarding the dimension of reflection-impulsivity and its theoretical and practical utility as a conceptual tool for understanding individual differences in performance on perceptual-cognitive tasks:

1. The labels reflective and impulsive are ambiguous and often imbued with surplus meanings. Since 1964, the MFF has been used as a classificatory instrument in a wide variety of research studies. Retrospectively, it seems clear that one of the overriding reasons for the popularity of the MFF as a research instrument is to be found in the substantial "extra" connotative meaning and psychological implications of the terms

impulsive and reflective. These two concepts are widely used (in natural language) and are "understood" and utilized by a variety of people in their efforts to understand the development and functioning of personality (Block, Block, & Harrington, 1974). Psychologists of various theoretical persuasions have used these (or closely related) terms in their theorizing or as the basis for organizing relationships between diverse variables (cf., Barratt, 1959; Sutton-Smith & Rosenberg, 1959). Social workers, child psychiatrists, educators, and laypersons also use the labels reflective and impulsive in implicative ways. Whatever the differences in the ways in which these terms are used by diverse professions, the central behavioral meaning of the terms seems to be sufficiently clear so that the users of these labels believe that they understand each other. Thus, the availability of an objective and easily administered method of indexing reflection-impulsivity in children was immediately attractive and generated a host of research.

Kagan has repeatedly defined R-I in very specific and narrow terms and as being operative only in situations of high response uncertainty in which the child must make a decision among simultaneously available alternatives. However, Kagan also repeatedly gives hints that he means R-I in its wider and more generally understood sense. For example, Kagan further characterizes impulsive children as being distractible, restless, hyperactive, non-anxious, emotionally uncontrolled, and risk-taking (see Kagan, 1965a, pp. 154-158; Kagan, 1966b, p. 124; Kagan et al., 1964, pp. 29-32; Kagan & Kogan, 1970, p. 1315). These additional qualities which Kagan imputes to the impulsive child (as well as those he attributes to the reflective child) strongly suggest that Kagan is often using the concept of R-I in its wider and generally understood meaning. (This is despite the possibility that Kagan may prefer to operationalize the concept via a procedure such as the MFF that is in line with his initial paradigm of decision time under conditions of uncertainty [Block et al., 1974]). In scrutinizing the rationale

underlying the use of the MFF, one can note a basic discrepancy between the way Kagan conceptualized reflection-impulsivity (in terms of response latency) and the way he then operationalizes the dimension (giving unspecified weight to response accuracy and response latency).

2. It is putting a heavy load on one measure to take it as the only and sufficient criterion of impulsive and reflective behavior. If conclusions relating R-I to cultural deprivation (Kagan, 1966b) and to diagnosis and educational practices (Kagan, 1965c) are to be postulated on the basis of MFF research, not only must the research be reliable, but the interpretation of the criterion measure of R-I (the MFF) must also rest on solid ground (Block et al., 1974).

The reliability of the MFF over time is not impressive (Messer, 1970). Furthermore, there is a concern regarding using an instrument for which no substantial standardization data is available. Reflection-impulsivity is defined (absolutely) only within a particular subgroup on the basis of that subgroup's median response time and errors. Yet a careful reading of the literature indicates that various investigators have classified children as reflective and impulsive solely on the response time measure. Given this, and given the fact that authors rarely specify which particular version of the MFF was used for R-I classification, extant data is hardly comparable.

Furthermore, the magnitude of the significant correlations reported in the literature between MFF scores and "school-achievement" measures is, on the whole, not very high. Often, due to large sample size, correlations in the range of .25 to .35 are significant--yet correlations of this magnitude account for less then 15% of the variance.

3. Because selection of subjects on the basis of the MFF is based on the double criteria of response latency and errors, it is not possible to determine the extent to which subsequent differences found between reflective (slow-accurate) and impulsive (fast-inaccurate) subjects are attributable to their differences in accuracy or to their differences in decision time.

To unconfound these two variables, it is incumbent on the investigator to include in the analysis those subgroups typically excluded in studies using the MFF: fast-accurates and slow-inaccurates. With very few exceptions (e.g., Ault et al., 1972), investigators have not looked at the performance characteristics of reflectives, impulsives, and the 20-40% of the children who are classified as neither reflective nor impulsive. For a complete (or even a reasonable) understanding of individual differences in cognition and their concomitants, investigators will have to include the data from the other 20-40% of their subjects.

4. The relative effects of R-I on performance are quite weak relative to the effect of other parameters such as instructions, age, and the specific parametric values of the stimuli employed (e.g., number and nature of feature differences). Thus, it is highly likely that factors other than R-I account for the largest portion of the variance in recognition memory, concept identification, and other experimental tasks.

The magnitude of the significant performance differences between reflective and impulsive children obtained in our research is singularly unimpressive. On an absolute basis, the differences between reflective and impulsive children in focusing ability was only 7% (Nuessle & Siegel, 1972). In Study 1, the difference between reflective and impulsive subjects in condition MFD (the one condition in which R-I differences were obtained) was 5%. In Study 2, the overall difference between reflective and impulsive preschoolers was 7%, and the greatest difference in a single condition (1FD) was 8+%. In Study 3, the overall difference between reflective and impulsive fifth graders was 5%, and the greatest difference in a single condition (1FD) was less than 8%. Only in Study 4 (in which the subjects were adults) were more substantial differences found; however, even in this study the overall performance difference was only 8%. To date, the single biggest difference we have found between reflective and impulsive subjects has been in condition 1FD in Study 4: Reflective adults made 14% more correct responses than did impulsive adults.

The issue here is one of statistical significance vs. theoretical and practical meaningfulness: "I come not to bury Caesar (R-I), but to praise him . . . For Caesar is an honorable (e.g., $p < .05$) man (effect) . . . Indeed, they are all honorable effects." The meaningfulness of such minimal, albeit consistent, differences leads the present author to question the fruitfulness of pursuing such "honorable" effects.

5. The data collectively argue against the position that the nature of the visual search process is different for reflective and impulsive subjects. Rather, there seems to be a quantitative difference in the thoroughness of the initial feature analysis performed. Performance differences between reflective and impulsive subjects are thus proposed to reflect points on a quantitative continuum (detailed feature testing) rather than to reflect qualitative process differences.

If this is indeed the case, then it is reasonable to question the appropriateness of referring to reflection-impulsivity as a dimension of "cognitive style." It was argued earlier in the paper that cognitive styles are different from "abilities" in that abilities concern the level (i.e., "quantity") of performance or skill, whereas cognitive styles emphasize the manner and form (i.e., quality) of cognitive performance. Our data seem to indicate that it might be more accurate to refer to children who are slow and accurate in their MFF performance as "feature-analytic in task approach" rather than as showing a "reflective cognitive style."

6. Rather than spending valuable subject time, research funds, and journal space in the demonstration of R-I differences in a number of additional tasks, future research might more profitably be directed towards investigating, manipulating, and understanding the specific conditions under which performance in any task might be enhanced for any child, reflective or impulsive.

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